

A SURVEY OF THE FAUNA AND FLORA OF ROCKY SHORES OF CARNAC ISLAND, WESTERN AUSTRALIA

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Carnac Island is a small island of 38½ acres surrounded on three sides by intertidal rock platforms similar to those of other limestone shores in the vicinity of Fremantle. These platforms vary both in width and degree of exposure to wave action and their study has helped considerably to an understanding of patterns of distribution of animals and plants on this type of rocky shore. Two visits were made by the writers to the island, the first on March 28, 1951 (recorded by Marsh, 1955) and the second between January 16-19, 1956. The latter was part of a more general survey of the island made by members of the Western Australian Naturalists' Club and the following account was originally issued as part of a mimeographed report of that survey.

The littoral environment of similar shores on Rottneſt Island is described briefly by Hodgkin, Marsh and Smith (1959). On these shores the animals and plants show a vertical zonation of the kind observed on rocky shores in other parts of the world, and the same zones are recorded below on Carnac Island. A horizontal zonation across the width of the level platforms is also described; the zones, distinguished by the dominant organisms, are: *Patelloida* (limpet), *Jania* (coralline alga), brown algae, lithothamnion (encrusting coralline alga). The use of the term "zone" for both vertical and horizontal zonation is perhaps confusing, but is retained here pending more detailed discussion elsewhere.

TOPOGRAPHY

Carnac Island is five nautical miles south-west of Fremantle and two miles north of Garden Island. It is composed of coastal limestone (eolianite) eroded from portion of a line of consolidated Pleistocene sand dunes from the Murray Reefs and Penguin Island in the south, through Point Peron, Garden and Carnac Islands, the Straggler Rocks, to east of Rottneſt Island (Fairbridge, 1948). A great part of the island is capped by a layer of travertine which has broken away abruptly at the coast where the wind has often eroded the soft rock beneath it; below this there are cliffs or fallen masses of soft rock and sand down to the level at which the rock is wetted by waves or splash. Here it is again hard, and eroded into a typical visor and notch (Fig. 2) or a ramp. Height of notch varies considerably from low notches with their deepest point at one foot above platform level on North Reef to notches rising to a visor at about 10 ft. and their deepest point at 6 to 8 ft. above the platform on S.W. Roek. Shore platforms surround much of the island (Fig. 1) and vary in width from 3 ft. (S.W. Roek) to about 200 ft. (West Reef). The eastern side is sandy with no platforms, although there

are small patches of rock at the base of the cliff in places. In contrast, the small Shag and Flat Rocks, north and south of the island, have distinct though narrow platforms on their eastern faces. The platforms terminate abruptly at their outer edges and, where examined, a sublittoral undercut is well developed. The Admiralty chart shows depths of up to 13 feet immediately round the island, but depths of 20 feet were found just off the edge of some of the platforms.

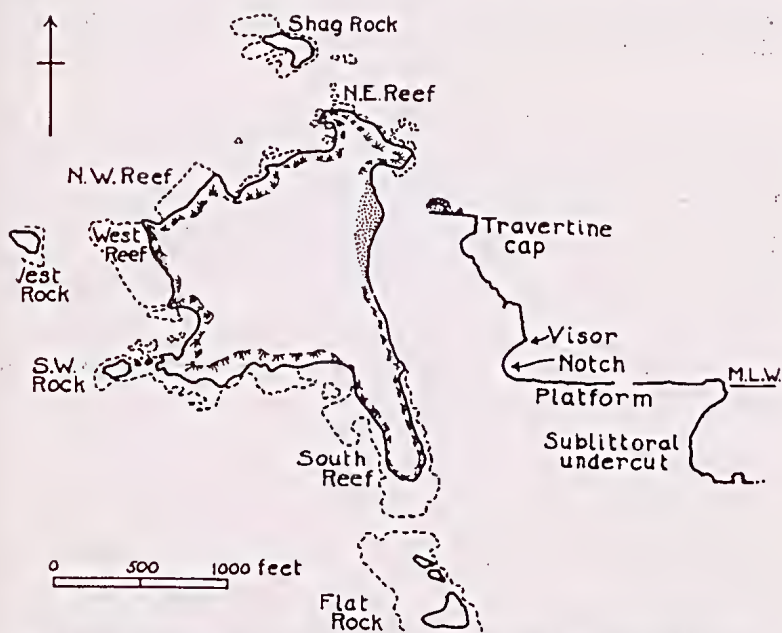


Fig. 1.—Carnae Island. Shore platforms and locations of reefs studied. Redrawn from survey by K. Tiller.

Fig. 2.—Typical shore profile.

WEATHER AND TIDES

The weather was fine and hot with easterly winds during the period of the survey. Tides were of typical summer pattern, with low water at about 7 am. and high water at 10 pm. each day, and ranged from a maximum height of 2.6 ft. to a minimum of 1.0 ft. above datum on the Fremantle gauge (January M.L.W. averages 1.25 ft.).

METHODS

Sketch plans of platforms studied were made from the cliff top, the principal measurements being determined on the ground. Fixed reference points were established on the shores and heights of these relative to Fremantle datum obtained by means of a portable recording gauge as described by Hodgkin (1956). Levels relative to the fixed points were obtained by horizon levelling and noted on the plans. Principal animal and plant associations were then plotted by observation and a traverse line across each platform selected for more careful study.

Along the traverse line a number of $\frac{1}{4}$ square yard (2.25 sq. ft.) sample areas were selected at random in each association. All the macroscopic animals within each square were counted and the algal species recorded. The results are summarised in Figs. 3 and 6. In these the animal populations are shown as being present, common, or abundant by lines of different thickness. Distribution of animal and plant associations are shown in Figs. 4, 5, 7 and 8.

Identifications were made by comparison with named material in our collections. Coral species have been named by Professor J. W. Wells to whom we are indebted. A list of all animal species found alive on the shores of Carnae Island is given in an appendix.

SOUTH REEF

The southern shore is bounded by narrow platforms which extend either from a notched cliff, at the southern tip, or from a deeply pocketed and dissected ramp rising 3-5 ft. above platform level on the south-west where the traverse was made. The platforms lie at about 1.5 ft. above datum with a narrow raised rim about 0.3 ft. higher. The platforms are exposed to moderate to strong wave action; they are open to the south-west but protected from the north-west.

A traverse was made across the reef where it faces west-south-west and the results are shown in Fig. 3. Distribution of the main associations is shown in Fig. 4.

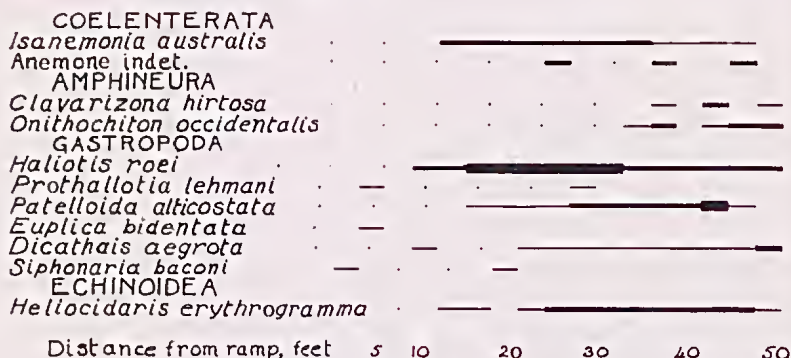


Fig. 3.—South Reef. Fauna found in traverse.

The commonest animal of these platforms was the mutton fish, *Haliotis roei*, which was present over the greater part of them. This was associated with a mixed algal turf of species of *Jania*, *Pterocladia*, *Ectocarpus*, *Laurencia*, *Hypnea*, *Dictyota* and *Cystophora*, short and sparse in some places and luxuriant in others. The horizontal zoning was less marked than on wider platforms; only in one part was there a narrow *Jania* zone of coralline alga with its associated fauna of small gastropods (area 8 in Fig. 4). The densest animal populations lay along the outer edge associated with a thick crumbly growth of lithothamnion, and the two chiton species were almost confined to this region. The fauna is typical of moderately wave-exposed shore platforms. The presence of *Balanus*

nigrescens and *Patellanax laticostata* in area 14 suggests that this part may be exposed to rather greater wave action. *P. laticostata* was also common on high rocks near the edge at one end of area 9. In area 10 there were large colonies of the zoanthid *Palythoa lecleri*, and *Zoanthus praelongus* was also present.

In the notch, above platform level, the zonation was typical of that found on other shores in the vicinity of Fremantle. The highest zone was occupied by the littorinids *Melaraphe unifasciata* and *Tectarius rugosus*; below this, in the region of wave wash, was a zone of small limpets—*Notoacmea onychitis* and a few *Patellanax peroni* (*Siphonaria luzonica* was not recorded from this shore). In

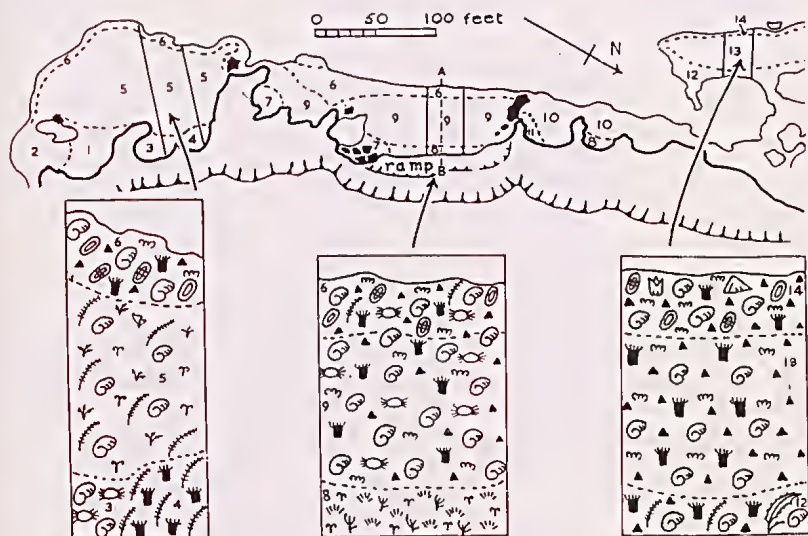


Fig 4.—South Reef. Animal and plant associations.

KEY TO SYMBOLS USED IN DIAGRAMS

ANIMALS

- Isanemonia australis*
- Zoanthus praelongus*
- Onithochiton occidentalis*
- Clavarizona hirtosa*
- Haliotis roei*
- Patelloida alticostata*
- Patellanax laticostata*
- Hormonya* sp.
- Balanus nigrescens*
- Patiriella gunii*
- Heliocidaris erythrogramma*
- Pyura pachydermatina*

PLANTS

- Ulva lactuca*
- Jania fastigiata*
- Hymea* spp.
- Pterocladia capillacea*
- Laurencia* spp.
- lithothamnion
- Sargassum* spp.
- Cystophora wifera*
- Ecklonia radiata*

the lower part of the notch there was a band of chitons, *Clavari-zona hirtosa* and *Poneroplax costata*, and below this *Patelloida alticostata* with, in sheltered places, the anemone *Actinia tenebrosa*.

SOUTH-WEST ROCK

This islet is surrounded by a narrow platform by which it is also attached to the main island; the platform is widest at the seaward end and only 2 or 3 ft. on the northern side. No traverses were made here, but distribution of the commoner animals and plants was plotted (Fig. 5). Levels were not taken, but most of the platform appears to lie at about 1 ft. above datum with raised areas on the narrow northern part.

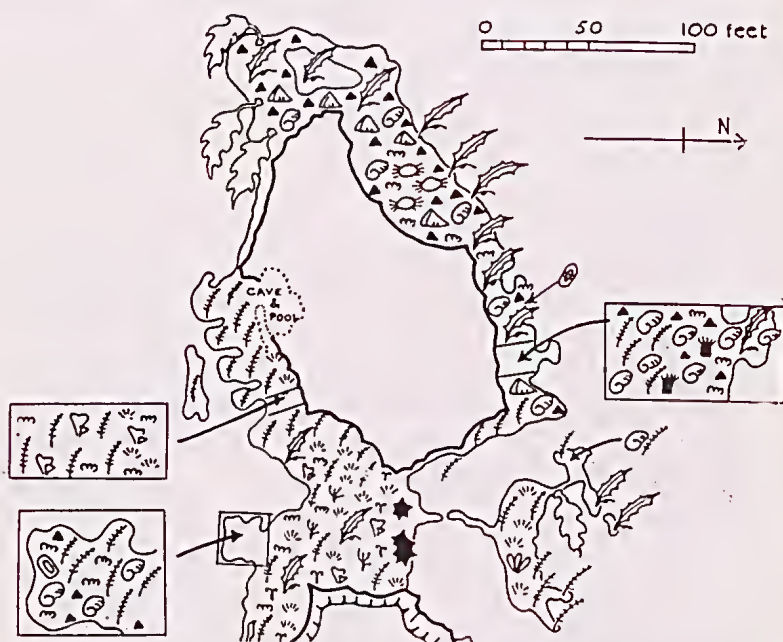


Fig. 5.—South-West Rock. Animal and plant associations.

Marked differences are evident in the plant and animal associations of this platform from the most wave-exposed western end to the relatively sheltered eastern part of the platform. At the western end *Patellanax laticostata* and *Patelloida alticostata* were common, with a few *Clavari-zona* but no *Isanemonia*; with these were associated lithothamnia, *Sargassum* and *Ecklonia*. The same animals were also common on the north-west, together with *Haliotis*, and there was a small area of deeply pocketed platform with abundant *Heliocidaris*. On the north, more sheltered side, *P. laticostata* largely disappeared and was replaced by *Isanemonia* and *Clavari-zona*; *Haliotis* was the dominant mollusc here. On all the eastern part of the platform animal populations were largely replaced by algae, mainly *Pterocladia capillacea*, and in the most

sheltered part there was a mixed algal turf dominated by *Jania*. *Pseudobonellia biuterina* was abundant on this part of the platform.

The notch varies in height around the islet, on the sheltered side its deepest point is not more than 3 ft. above the platform while on the exposed side it is 6 or more feet. The animal zones were correspondingly raised. In an exposed place the zones were; a band of filamentous green algae replacing the usual littorinids; a mixed limpet zone of *Notoamea*, *Patellanax peroni*, *P. laticostata*, with *Clavarizona*, *Onithochiton*, *Poncroplax*, and a few *Balanus nigrescens*; and below this *Patelloida*, *Actinia*, *Haliotis*, and lithothamnion. Where there was more shelter from wave action there were no *Onithochiton*, *Poncroplax*, *Balanus*, *P. laticostata* or *P. peroni*.

WEST REEF

This wide platform extends westwards from a sandy beach at the north-west corner of the island (Smith Point). The platform is fairly high, about 2 ft. above datum, and appears to be moderately exposed to wave action. Sand from the beach spreads on to it and modifies the distribution of animal and plant associations (Fig. 7). A traverse was made across the platform and the results of this are shown in Fig. 6.

At the shore, a partially exposed rock ramp was populated with patches of mussels, *Hormomya*, and the pulmonate limpet *Siphonaria baconi*. From the ramp the following associations succeeded one another across the platform: (a) *Jania* zone with much sand; (b) shallow pool; (c) a short turf of coralline algae with some *Sargassum*, *Dictyota*, *Colpomenia* and *Hypnea*; (d) an outer zone of lithothamnion with a fairly dense population of browsing molluscs (*Haliotis roei*, *Patelloida alticostata*, *Patellanax laticostata*

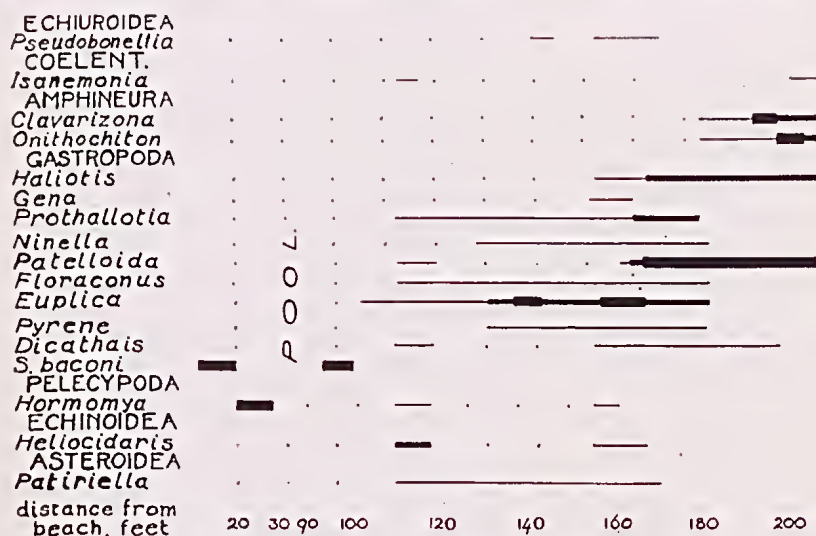


Fig. 6.—West Reef. Fauna found in traverse.

(few), *Onithochiton occidentalis* and *Clavarizona hirtosa*) with a few *Isanemonia australis*. Chitons are confined to the outer part of the zone.

On parts of the reef lower than the general level *Sargassum* and *Pterocladia* predominate. Occurring on the reef flat, between 135 and 180 ft. from the ramp, were these additional species, one specimen of each being found in the traverse: *Cryptoplax iredalei*, *Gomnolla* sp., *Mitra* sp., *Bellastrea* sp., *Notoacmea onychitis*, *Austrocochlea rudis*, and a few *Notogibbula preissiana*. *Ravitrona caputserpentis* was found here in the 1951 visit.

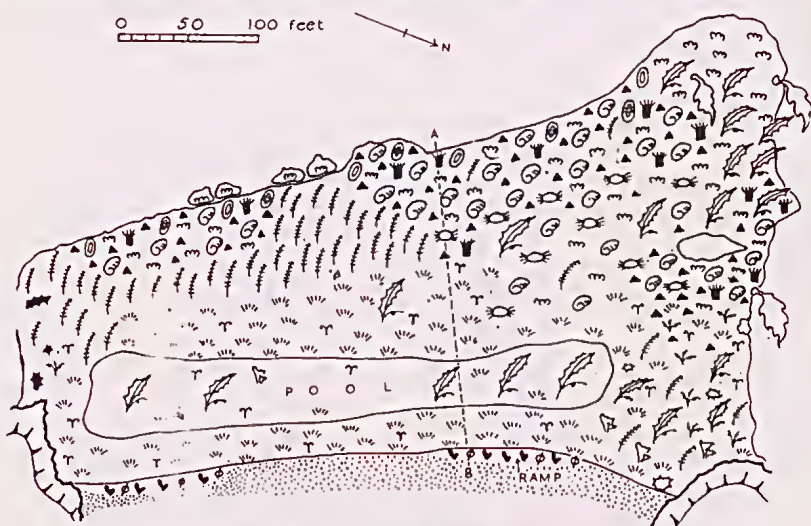


Fig. 7.—West Reef. Animal and plant associations.

NORTH-WEST REEF

This platform is about 120 ft. wide, but is dissected by several deep pools. It extends from the foot of a cliff with a low notch (deepest part about 1 ft. above platform level) and a wide overhang. Facing north-west, the platform is relatively sheltered. Levels are shown in the diagram (Fig. 8). No traverse was made.

Animal and plant associations are plotted in the diagram. These are horizontally zoned as follows: (a) an inner *Jania* zone of coralline turf with some *Sargassum* and sand, at about 1.5 ft. above datum, *Patiriella gunnii* was abundant in this zone; (b) algal zone of *Sargassum* with *Pterocladia*, *Hypnea*, *Laurcncia*, *Ulva*, *Jania* and patches of *Cymodocea*, this was deeply pocketed and at a relatively low level (1.0-1.3 ft. above datum), *Pyura pachydermatina* var. *gibbosa* occurred here; (c) at the reef edge a narrow raised rim, at about 1.5 ft., on which a modified *Haliotis-lithothamnion* association was present.

The notch showed a sparse population, with only a few littorinids, *Melaraphe* and *Tectarius*; the limpet zone was dominated by *Notoacmea onychitis* with *Siphonaria luzonica* and a few *Patellanax peroni*; lower down were *Patelloida alticostata* with a few

Poneroplax and *Balanus*. The alga *Gelidium* occurred at the base of the notch and in places a tube-building polyehaete of the family Sabellariidae was plentiful.

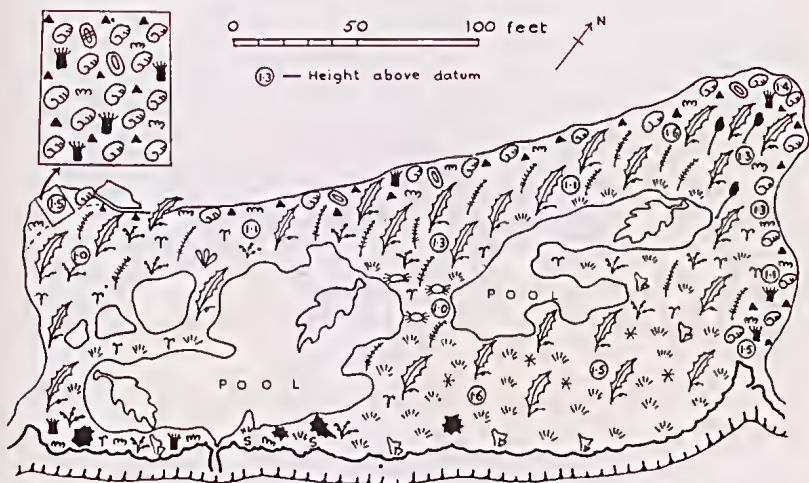


Fig. 8.—North-West Reef. Animal and plant associations.

NORTH-EAST REEF

On the northern tip of the island there are narrow, dissected platforms, 30 ft. wide or less. They are sheltered from wave action and provide a contrast to the more exposed platforms of other shores of the island.

We were not able to examine these platforms, but a survey of one was kindly made after our departure by J. A. L. Watson. The greater part was covered by a turf of coralline algae and sand with *Isanemonia*, *Patelloida*, *Euphica*, *Gena*, *Ninella* and *Hormomya*. The outer edge lacked the dense animal populations of wave-exposed platforms and was covered with *Sargassum* and *Pterocladia* with little lithothamnion and with a similar fauna to the rest. *Patelloida* was the only macroscopic animal species living on the rock surface, other species present being browsers on the algae, predators, detrital and plankton feeders.

DISCUSSION

On this small island of irregular shape there are considerable environmental differences between the various shores; differences of aspect and consequent wave action, of platform level and width, and in the presence or absence of sand. These variables can seldom be completely separated, nevertheless it is often possible to understand how they influence observed differences of plant and animal associations on the various shores.

The effect of sand is well seen on W. reef which is backed by a beach; sand accumulates over the inner platform and the faunal

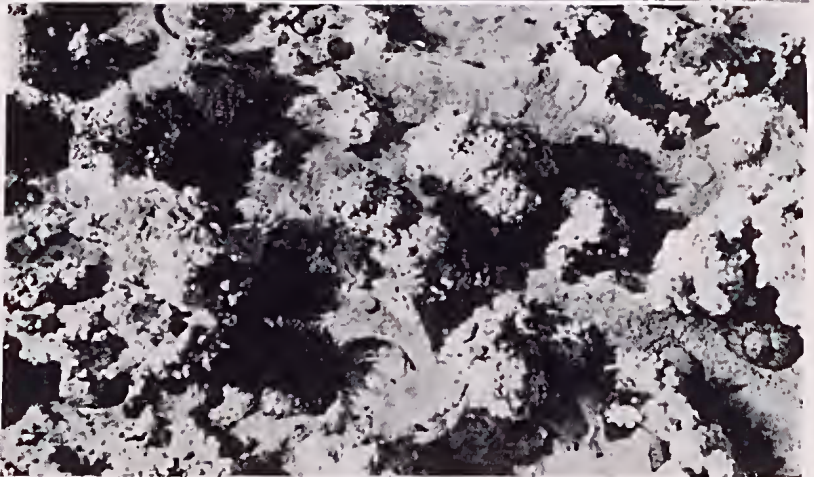


PLATE I
(Explanation at foot of opposite page)

poverty here is in marked contrast to the outer 20 ft. of platform. Sand is also retained among *Jania* on the inner part of N. Reef platform and again there is a restricted macrofauna. The same conditions exist over most of the N.E. platform. In contrast to these, S. and S.W. platforms are largely free of sand and carry an abundant and rich fauna and large algae.

Wave action is greatest at the outside edge of platforms and, irrespective of aspect, there is here both the greatest mechanical pounding and the most frequent renewal of water at low tide. The richest and most diversified fauna is found here, associated with a thick encrustation of lithothamnion, and this outer "lithothamnion zone" is present on all Carnac platforms (except N.E.). Even on the narrow S. Reef platform there is an evident change in composition of fauna and flora across the width of the platform; along the traverse line chitons and thick lithothamnion are confined to the outer 15 ft., and there is a narrow inner *Jania* zone with the associated small gastropods. Differences of level sometimes complicate this effect of distance from the outer edge; changes across the N.W. platform are probably partly attributable to this, the lower levels favouring a stronger growth of large algae.

The effect of differences of aspect is shown particularly well by the various animal and plant associations of the narrow platform surrounding S.W. rock, described above. It is unfortunate that time did not permit a more detailed survey here. Differences in the nature of the associations with aspect are also seen by comparison of the various platforms. *Patellanax laticostata* and *Balanus nigrescens* only occur on the outermost parts of S. and S.W. platforms (the most exposed situations), while elsewhere on the south and west shores of the island *Haliotis roei* dominates the lithothamnion zone. The associated fauna is similar in exposed and moderately exposed places, consisting of *Clavarizona*, *Patelloida*, *Isanemonia*, and *Onithochiton*, while *Helicoidaris* occurs in deeper pockets. Chitons were few on the most exposed part of the platform of S.W. Rock but plentiful in the notch. This zone, with much the same fauna, is present round the edge of the more sheltered N.W. platform, but here only as a belt about a yard wide, except on the western corner. It is altogether absent from the sheltered N.E. platform where algae, mainly *Sargassum* and *Pterocladia*, occur right to the edge of the platform. Differences of exposure to wave action are also reflected in the fauna of the notch. This is particularly noticeable on S.W. Rock where a number of species of the lithothamnion zone were present in the lower notch in the most exposed situation, but are absent from more sheltered places.

The fauna of Carnac Island shores is similar in composition to

Fig. 1 (top).—Coast at N.E. Reefs, N.E. Reefs, showing travertine cap, cliff and notch. Platform in foreground submerged. Fig. 2 (middle).—Notched rock on platform at S.W. Rock, Fig. 3 (bottom).—Lithothamnion zone on W. Reef. Photo shows thick lithothamnion encrustation, *Isanemonia australis*, *Haliotis roei* (with *Patelloida nigrosulcata*), *Patellanax laticostata*, *Patelloida alticostata*, *Clavarizona hirtosa* and *Isanemonia australis*.

that of Garden Island and Point Peron in that most of the species have a southern distribution. Tropical species abundant on Rottneest Island ten miles to the north-west are represented by a few species only; the zoanthids *Zoanthus praelongus* and *Palythoa heideri*, a few specimens of the cowrie *Ravitrona caputserpentis* and, in the sub-littoral, two species of coral.

ACKNOWLEDGMENTS

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APPENDIX I.—ANIMAL SPECIES FOUND ALIVE IN SURVEYS OF SHORE PLATFORMS.

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| Coelenterata, Actiniaria | Mollusca, Amphineura |
| <i>Actinia tenebrosa</i> Farquhar | <i>Clavarizona hirtosa</i> Blainville |
| <i>Isanemonia australis</i> Carlgren | <i>Poneroplax costata</i> Blainville |
| <i>Cnidopus verater</i> (Drayton) | <i>Onithochiton occidentalis</i> Ashby |
| anemone, gen. et sp. indet. | <i>Cryptoplax</i> sp. |
| Coelenterata, Madreporaria | Mollusca, Gastropoda |
| <i>Favites magnistellata</i> (M.E. & H.) | <i>Haliotis roei</i> (Gray) |
| <i>Platygyra lamellina</i> (Ehr.) | <i>Patellanax peroni</i> (Blainville) |
| <i>Plesiastrea urvillei</i> (M.E. & H.) | <i>Patellanax laticostata</i> (Blainville) |
| Coelenterata, Zoanthidea | <i>Patelloida alticostata</i> (Angas) |
| <i>Zoanthus praelongus</i> Carlgren | <i>Notoacmea onychitis</i> (Menke) |
| <i>Palythoa heideri</i> Carlgren | <i>Gibbula preissiana</i> (Philipp) |
| Annelida, Polychaeta | <i>Prothallotia pulcherrima</i> (Wood) |
| Fam. Sabellariidae, gen. et sp. indet. | <i>Prothallotia lehmani</i> (Menke) |
| Echiuroidea | <i>Austrocochlea rudis</i> (Gray) |
| <i>Pseudobonellia biuterina</i> Johnston | <i>Gena auricula</i> (Lamarek) |
| & Tlegs | <i>Ninella whiteleyi</i> Iredale |
| Arthropoda, Cirripedia | <i>Bellastrea</i> sp. |
| <i>Balanus nigrescens</i> Lamarek | <i>Melanerita melanotragus</i> (Smith) |
| <i>Tetraclita purpurascens</i> (Wood) | <i>Melaraphe unifasciata</i> (Gray) |
| Echinodermata, Echinoidea | <i>Tectarius rugosus</i> (Menke) |
| <i>Helicoidaris erythrogramma</i> (Valenciennes) | <i>Ravitrona caputserpentis</i> (Linne) |
| Echinodermata, Asteroidea | <i>Floraconus anemone</i> (Lamarek) |
| <i>Patriella gunnii</i> (Gray) | <i>Euplica bidentata</i> Menke |
| <i>Petricia obesa</i> H. L. Clark | <i>Pyrene</i> spp. |
| Chordata, Tunleata | <i>Dicathais aegrota</i> (Reeve) |
| <i>Pyura pachydermatina</i> Herdman | <i>Cominella</i> sp. |
| var. <i>gibbosa</i> Herdman | <i>Mitra</i> sp. |
| | <i>Siphonaria baconi</i> Reeve |
| | <i>Siphonaria luzonica</i> Reeve |
| | Mollusca, Pelycypoda |
| | <i>Hormomya</i> sp. |